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The larva of *Podolestes orientalis* from West Malaysia, with notes on its habitat and biology (Odonata: Megapodagrionidae)

Chee Yen Choong [1] & Albert G. Orr [2]

[1] Centre for Insect Systematics, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia. <cychoong@ukm.my>
[2] CRC Tropical Ecosystem Management, AES, Griffith University, Nathan, Q 4111, Australia. <agorr@bigpond.com>

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Abstract

The larva of the south-east Asian megapodagrionid, *Podolestes orientalis*, is described and figured. Specimens were collected from shallow forest pools lined with large dead leaves in secondary lowland forest. Final and earlier stadium larvae were found concentrated around the edges of pools in very shallow water. Larvae sometimes perched in exposed situations, just below the water surface, with abdomen upturned and caudal lamellae splayed outward to expose the broad respiratory surfaces. This represents the first account of the immature stages for this south-east Asian genus. The caudal lamellae are very broad and flattened, inserted horizontally, suggesting a close relationship between the genus *Podolestes* and Australian region megapodagrionids.

Introduction

The south-east Asian megapodagrionid genus *Podolestes* Selys includes eight species, five from Borneo, three from Sumatra, two from Peninsular Malaysia and one relatively recent discovery from Hainan (Wilson & Reels 2001). By far the most widespread species is *P. orientalis* Selys (Plate IVa), which occurs in swampy forest and along slow, sluggish, lowland forest streams throughout Borneo, Peninsular Malaysia and Sumatra (Lieftinck 1954; Orr 2001, 2003).

To date, the larvae of *Podolestes* have proved elusive. Lieftinck (1935, 1950) reported or implied searching for larvae of *Podolestes* spp. in Sumatra and southern Borneo without success. Both AGO and V.J. Kalkman independently conducted thorough but fruitless searches for larvae of *P. orientalis* in Brunei, concentrat-

ing on situations in alluvial swamp and peatswamp forests where the adults were particularly numerous and females had been observed ovipositing (localities described in Orr 2001). Other experienced collectors have lately sampled suitable habitat in Sarawak, again without success (Dow 2009; Dow & Reels 2009).

Recently, one of us (CYC), discovered a number of late stadium megapodagrionid larvae in a shallow, leafy, forest pool on the campus of the Universiti Kebangsaan Malaysia (UKM), Bangi, West Malaysia. Several were bred to adulthood producing adults of both sexes of *P. orientalis*. The morphology of final stadium (F) larvae, and what we could discover of their habits are described here.

Area and methods

Larvae were found in a shallow leaf lined pool in a swampy low-lying patch of secondary forest on the UKM Bangi Campus. Adults were present at the site in moderate numbers, and the extent of suitable breeding habitat covered ca 0.5 ha. Larvae were collected using a dip net. Samples were taken from various depths of the pool, with locations of larvae noted. The vegetation of the surrounding area was also searched thoroughly for exuviae, to a height of 2 m.

Larvae collected were retained in the laboratory in plastic containers and fed on small tadpoles. Three individuals (2 ♂, 1 ♀) were allowed to emerge on sticks provided for this purpose. The remainder were preserved in absolute ethanol. Specimens were photographed in life, in the field and the laboratory using digital camera Canon EOS 300D. Preserved specimens were examined and dissected under a stereo microscope and figures prepared with the aid of a drawing tube.

Larva of *Podolestes orientalis*

(Fig. 1, Plate IVb)

Specimens examined

5 ♂, F; 7 ♀, F; 4 ♂, F-2 or younger; 1 ♀, F-2 or younger. All collected 21-22 ii 2009, from UKM, Bangi Campus, Malaysia. 1 ♂ exuvia, same locality, 26 iv 2009.

Diagnosis

A moderately robust zygopteran with long legs and greatly expanded caudal lamellae set in the horizontal plane to form a broad fan, comprising about one third of the total body length (Fig. 1a, Plate IVb). Ground colour of body dark russet brown to light sepia; caudal lamellae with series of 3-4 indistinct lighter bands; legs paler brown with femora strongly and distinctively banded.

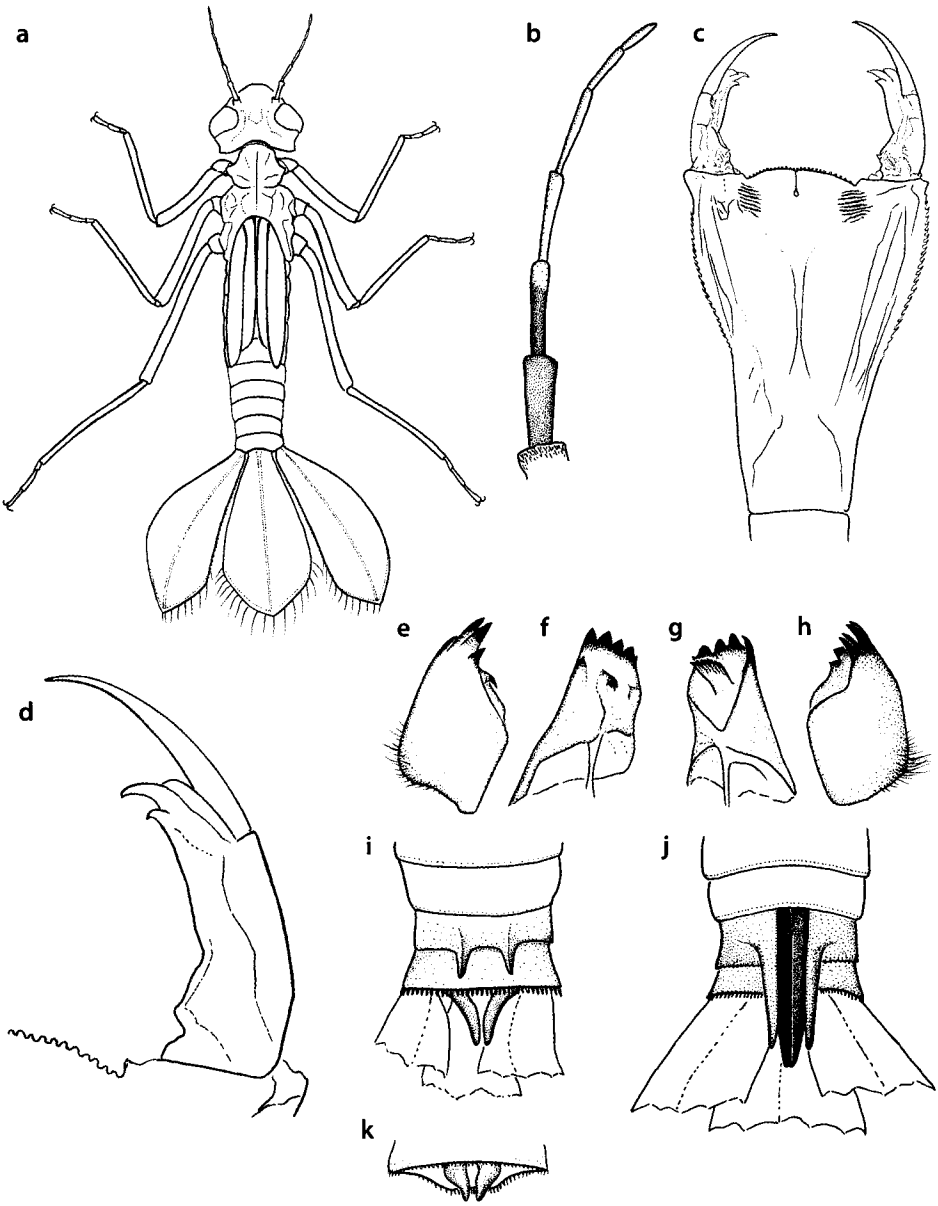

Figure 1: Details of the larva of *Podolestes orientalis* — (a) habitus of final stadium; (b) antenna; (c) prementum and labial palps, dorsal view; (d) detail of labial palp, ventral view; (e) right mandible, ventral view; (f) same, interior view; (g) left mandible, interior view; (h) same, ventral view; (i) ventral view of male abdomen showing gonapophyses and cerci; (j) ventral view of female abdomen showing gonaphophyses; (k) ventral view of female S10 showing cerci, partly concealed by gonapophyses in intact specimens. Not to scale.

Description

Head: Relatively broad, exceeding maximum breadth of mesothorax; in dorsal view general shape a compressed pentagon, with the posterior side excavated to form approximately a shallow sinusoidal margin; anterior angles of head in dorsal profile slightly pointed. Antennae 6-segmented (Fig. 1b), moderately long and evenly tapered. Labium (Fig. 1c) elongate; prementum almost twice as long as broad, narrow basally. Lateral margins of distal half with well-defined forward pointing small curved teeth. Distal lobe shallow with strong crenulations; median division moderately short. Lateral parts of median lobe with pair of roughly ovoid areas of fine, raised striae, distinctive when seen in proper light but easily overlooked. Labial palp (Figs 1c, d) robust, lacking large setae; basally with distinct thickening and, on dorsal surface with slightly roughened area furnished with a small inner denticle; distally with three robust, short, incurved teeth; movable hook long and robust. Maxilla with stipes elongate, twice as long as broad. Galea and lacinia partly fused, total length, with spines, equal that of stipes; inner margin of lacinia with seven long robust setae medially; lacinia terminating in four long sharp spines, forming a curved, inward-directed, pitchfork-like structure; galea with three shorter spines directed upward. Palp with short basal segment and a single long banana-shaped terminal segment, reaching to base of most distal spines on galeo-lacinea, covered in dense long setae for the distal two-thirds of its length. Mandibles as illustrated (Figs 1e-h). Right mandible with four well developed incisors with a rudimentary fifth, innermost tooth; outermost (ventral) tooth with small secondary tooth well before its apex; molar crest produced to form a well-defined curved trifid spine, the division apparent when viewed from inside. Left mandible with similar incisors, but lacking basal secondary spine associated with longest, outermost tooth; molar crest produced into a long straight, securiform process with its distal edge serrated with 6-7 fine denticles.

Thorax: Prothorax trapezoidal, shallowly concave above and shield-like, laterally produced to form semi-acute blunt processes around the midpoint of the margin. Meso- and metathorax irregularly convex above. Legs long and thin, with the metathoracic legs 1.75 times as long as prothoracic legs, the increase in length being disproportionally due to progressive elongation of the femur. Femora typically with three distinct dark bands, terminal, subterminal and subbasal, the latter especially sometimes obscure. Tibia with narrow dark basal band and slight obscure darkening terminally, not always evident. Wing sheaths long, parallel sided, flat and narrow, reaching to beyond distal margin of S5.

Abdomen: Moderately robust and elongate. Gonapophyses well developed in male, projecting from posterior margin of S9 across three quarters of width of S10 (Fig. 1i). In female outer gonapophyses projecting well beyond posterior margin of S10; inner gonapophyses reaching still further (Fig. 1j). Cerci in male long,

moderately thin and bent evenly outwards, easily visible in ventral view; in female cerci shorter, more conical, partly concealed by gonapophyses in ventral view (Fig. 1k). Caudal lamellae broad and flattened, horizontally oriented and seated fan-wise in S10. Laterals longest, ca 1/3 to 4/5 of total body length, asymmetrical leaf shape; inner margin serrate with short setae. Median lamella broader and slightly shorter; symmetrical broad spoon shape, broadest distally. All lamellae with transverse barred pattern of about three pale bands, obscure basally; terminally fringed with long fine setae. There is some variation in the shape of these lamellae, especially the central one, being in some specimens rather squarer in outline than others. In one specimen examined the median lamella, which was obviously regenerating following injury, was thin and lanceolate, and only ca 2/3 the length of the laterals.

Microhabitat and behaviour

Larvae were found exclusively among fallen submerged or semi-submerged leaves and sticks at the shallow edge of the pool, down to 10 cm depth. The pool, at its deepest point near the middle, was ca 2-3 m deep, but dredging in deeper water yielded no specimens, In fact, the best way of catching them was to remove leaves and sticks at the water edge careful to reveal them and then catch them between finger and thumb. Often larvae were found between two broad dead leaves, part of which sometimes protruded above the water. Larvae were also seen sitting exposed on leaves, their abdomen curved upwards and their caudal lamellae splayed and reaching to just beneath the water surface (Fig. 2). Sometimes they adopted this posture with the head half hidden between leaves, but the respiratory surfaces raised and exposed.

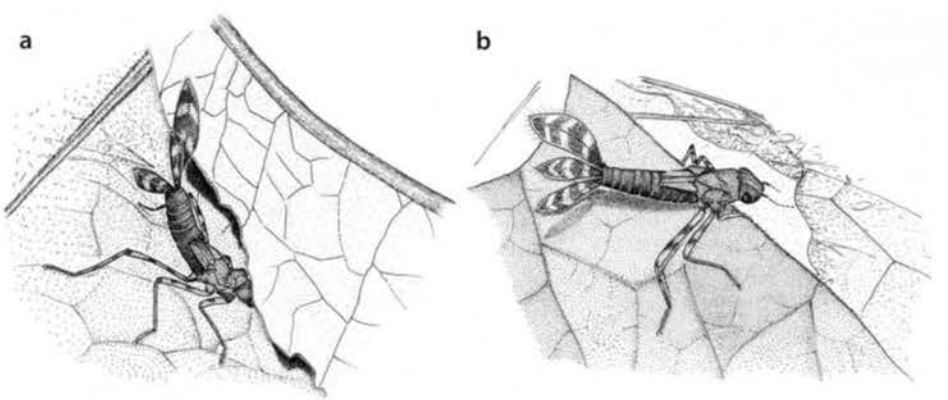

Figure 2: Final stadium larva of *Podolestes orientalis* in life exposing caudal lamellae — (a) head hidden among leaves; (b) perched in open shallow water.

A single male exuvia was found near the larval habitat. It was hanging from a dead leaf 15 cm above the ground under the wild ginger plants (*Etlingera metriocheilos*) growing beside the pool. The exuvia was ca 15 cm from the water's edge. Given the low numbers of adults, with never more than two adults ever observed at any given time, there was no reason to expect larger numbers of exuviae, hence this may well have represented a typical emergence site. In the laboratory, emergence of all three specimens took place during the day, after 08:30 h.

Discussion

The form of the larva of *Podolestes* has long been a matter of conjecture and special interest. Of three megapodagrionid genera known from Sundaland, only the larvae of *Rhinagrion* spp. were previously known (Lieftinck 1956; Orr 2003); in this genus the caudal lamellae in death appear as three stubby, slightly swollen, vertically aligned plates. The tracheation is distinctive (Lieftinck 1956). In many other members of the family the caudal lamellae are strongly flattened and set in a horizontal plane (Lieftinck 1956, 1976; Theischinger 1998), and in yet others the lamellae are saccoid (Paulian 1958; Novelo-Gutiérrez 2008), or triquetral-elongate (Pérez-Gutiérerez 2007).

Based on the general structure, and horizontal placement of the gills, larva of *Podolestes* are clearly of the same general form as those of *Argiolestes* and related genera found to the east in New Guinea (Lieftinck 1956), New Caledonia (Lieftinck 1976) and Australia (Lieftinck 1976; Theischinger 1998) to east. The Madagascan *Nesolestes* (Schütte 2010) and possibly *Protolestes* (Paulian 1958), also share this body plan. Within this group, there is considerable variation in body shape, relative size, shape and terminal filaments of the caudal lamellae, shape of the prementum, shape and armature of the labial palp, as well as smaller structures not considered here. Lieftinck (1976) also illustrates substantial variation in the development of the molar region of the mandibles. This is remarkable because this character appears to be generally very conservative among other Zygoptera, with structures very similar to those reported here for *P. orientalis* appearing in such diverse groups as such as the Neotropical megapodagrionids *Heteragrion* spp. (De Marmels 2003), *Paraphlebia* (Novelo-Gutiérrez 2008) and *Teinopodagrion* spp. (Pérez-Gutiérrez 2007), as well as the amphipterygid *Amphipteryx* (Novelo-Gutiérrez 1995) and probably the polythorid *Polythore spaeteri* Burmeister & Börzsöny (Etscher et al. 2006).

The most striking feature of the larvae of *P. orientalis* is its similarity to that of the Australian *Austroargiolestes icteromelas* (Selys) and other less well-documented *Austroargiolestes* spp. This is true of its general habitus and many structural details. The similarities are all the more remarkable given that, although both species

are widespread and fairly eurytopic within their habitats, *A. icteromelas* is primarily an inhabitant of clear, flowing, well-aerated streams, where it is found under stones and undercut banks, sometimes flattened against the substrate (Lieftinck 1956), whereas *P. orientalis* adults occur around shallow stagnant forest pools and only on the slowest flowing of forest streams, normally near to where they drain into extensive swampy areas (Orr 2001). It would be difficult to argue that the similarities arose from convergence due to similar life styles and habitats. The following differences may be noted: *P. orientalis* larvae are slightly more elongate than those of *A. icteromelas*, and the caudal lamellae are relatively broader but shorter. The mask is somewhat longer and more abruptly expanded than in *A. icteromelas*. Correspondingly the stipes of the maxillae are also slightly longer. The process on the molar crest of the left mandible is longer and straighter. That on the right mandible differs in minor details of dentition. The form of the labial palps is very similar in the two species but those of *P. orientalis* are relatively slightly longer. Distal dentition is almost identical, but only in *P. orientalis* is there a small tooth and roughened area at the base of the labial palp. Furthermore, the small, striated patches on the inner face of the prementum have only been reported in *P. orientalis*, and may represent a synapomorphy. They are situated in much the same area as are found setae in many other odonates, suggestive of a grasping function. They could not be discerned by us in *A. icteromelas* but we note however that the character might easily be overlooked and its failure to be recorded in other published descriptions of megapodagrionid larvae cannot be taken as proof of its absence. The legs are proportionally slightly longer in *P. orientalis*, perhaps an adaptation to its still water habitat and sprawling habits. As far as we know, the habit of perching with abdomen turned upward and gills splayed is unknown in *A. icteromelas*. This may relate to low oxygen content on the forest pools frequented by *P. orientalis*. In conditions found in tropical forests with very high rates of decomposition it is possible that only the upper layers of water, within one cm of the surface, are well oxygenated. The habit documented here (Fig. 2) may be a strategy to expose the maximum area of respiratory surface to the highest concentrations of oxygen. Such behaviour was reported by odonates dwelling in oxygen depleted phytotelmata in Bornean rainforest by Orr (1994) and it would be interesting to discover if the phytotelm dwelling megapodagrionid *Podopteryx* spp. of north Queensland and New Guinea adopt a similar posture.

If the behaviour reported here is typical, it is difficult to understand why no larvae could be found in searches of similar habitat in Borneo. The answer may be that the precise microhabitat is quite specialized, and in extensive swampy areas in alluvial floodplains or peat swamp larvae may be confined to many small but highly specific sites, which are not to us obviously different from the much greater area of apparent potential habitat available in such areas. In the secondary forest on the UKM campus, suitable habitat was quite limited and hence much more

easily sampled, and indeed, the proportional area of suitable habitat relative to other shallow water habitat might have been far greater than in the pristine Bornean sites sampled by Orr (2001) and others.

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